1.0	**TECHNOLOGY NAME**	LIGHT-WEIGHT FLEXIBLE SOLAR ARRAY
2.0	**SPONSORSHIP**	Modular and Multifunctional Systems (MAMS)
2.1	**IPDT SPONSOR**	Phillips Lab & Lockheed Martin (LM)
2.2	**TEAM MEMBERS**	John Lyons/734, 301-286-3841 Bill Hayden/721, 301-286-8963 Richard Broderick/734, 301-286-4225 Alphonso Sterwart/722, 286-5560 Chuck Engler/723, 286-7534

3.0 OVERVIEW

This validation plan pertains to the lightweight flexible solar array (LFSA) experiment. This experiment consists of a flexible copper-indium-diselinide (CIS) blanket suspended in a composite frame. The frame is deployed using shape memory alloy (SMA) hinges and launch restraint device.

The overall objective of the experiment is to demonstrate controlled deployment of a solar array with >100 watt/Kg efficiency.

Based on this, specific experiment objectives have been divided into those that pertain to shape memory mechanisms and evaluating CIS under on-orbit conditions. Thus the engineering validation objectives are:

1. Controlled LFSA Deployment;
2. Thin Film Flexible CIS Photovoltaics Performance Evaluation.

4.0 INTRODUCTION

Photovoltaic (PV) arrays are the primary sources of electrical power for geosynchronous and low-earth-orbiting satellites. The LFSA technology could provide higher power-to-weight ratios (specific energy) than conventional solar arrays, thus allowing a higher science payload mass fraction. Current solar array technologies provide specific energies in the range of 20-40 Watts/Kg when the solar array deployment system and the solar array drive are considered. This technology could provide specific energies greater than 100 Watts/Kg.

Silicon (Si), Gallium Arsenide on Germanium (GaAs/Ge), and multi-junction (MJ) solar cells are technologies that involve cystal growth on a fragile wafer. The CIS thin film solar cell technology is vapor deposited on a flexible substrate which is substantially lighter than cells bonded to a rigid panel. The SMA also provides substantial weight savings over conventional hinges, deployment systems, and solar array drives. Therefore, a combination of these technologies provides significant improvement in the power-to-weight ratios. The shockless deployment could improve the spacecraft dynamics during deployment, and also is much safer to handle,integrate and test that conventional pyros. It is also electrically resettable so that the same device flies that is tested. The SMA deployment/hinge devices are significantly cheaper, simpler and therfore more reliable than current technology.

5.0 TECHNOLOGY DESCRIPTION

The candidate technology is a lightweight photovoltaic solar array system. The unique features of this solar array are the use of copper indium diselinide ($CuInSe2$ or CIS) solar cells and shape memory alloys (SMA) for the hinge and deployment system.

6.0 TECHNICAL VALIDATION OBJECTIVES

The lightweight flexible solar array experiment consists of a flexible CIS blanket suspended in a composite frame. The frame is deployed using shape memory hinges and a launch restraint device.

The overall objective of the experiment is to demonstrate controlled deployment of a solar array with >100 watts/Kg efficiency.

Objectives for this experiment have been divided into those that pertain to shape memory mechanisms and evaluating the electrical performance of the CIS array under on-orbit conditions.

6.1 CONTROLLED LFSA DEPLOYMENT

6.1.1 Required Data

a. Deployment Power: Current dissipated in shape memory hinges

b. Launch Restraint Status: Binary switch that indicates the LFSA is released.

c. Deployment Status: Binary switch that indicates the LFSA is fully deployed.

6.1.2 Approach

Use shape memory actuation to release launch retention mechanism followed by activation of shape memory hinges.

6.1.3 Anticipated Results

LFSA deployment into on-orbit position.

6.1.4 Integration and Testing Data

Ground testing will include functional testing of deployment system following thermal cycling, vibration and acoustic environment exposure. Shape memory actuator reliability and reproducibility will be evaluated during cyclic functional testing.

6.1.5 Rationale

Correlation between ground test results and expected LFSA behavior will be used to validate objective. On-orbit data will be used to quantity SMA deployment behavior.

6.2 THIN FILM FLEXIBLE CIS PHOTOVOLTAICS PERFORMANCE EVALUATION

Evaluate the thin film CIS photovoltaics combined environment on-orbit response, including;

a. Thermal vacuum.

b. Thermal cycling.

c. Radiation.

d. Atomic oxygen.

6.2.1 Required Data/Necessary Measurements

a. Array current.

b. Array voltage.

c. Array temperature.

d. Solar insolation.

e. Natural radiation and atomic oxygen levels.

6.2.2 Approach

The CIS segment will be monitored and trended by mission operations. Array current, voltage, and temperature analog data will be telemetered and used for performance/degradation assessment. The solar insolation will be either monitored by the primary solar array instrumentation or inferred from the primary array electrical performance. Both the natural radiation and atomic oxygen levels will be calculated based upon the orbital parameters and the industry standard environment models.

6.2.3 Anticipated Results

Verification of the thin film CIS under actual on-orbit combined environment conditions.

6.2.4 Supporting Integration and Testing Data

Flight array current-voltage (I-V) performance and continuity will be measured prior to integration with the solar array structure and integration with the spacecraft. Ground tests of the thin film CIS PV blanket structural and electrical interfaces as a function of temperature will be demonstrated in ground testing.

6.2.5 Rationale

The results of this flight experiment will validate the on-orbit response of an integrated thin film CIS array response and provide validated models for future spacecraft power system design.

7.0 SCHEDULE

Deploy LFSA, verify status, deployment power, acquire PV performance data.

LFSA Deployment Sequence

10 sec max
Launch Restraint
120 sec max
Panel 1 Deployment
120 sec max
Panel 2 Deployment
Δ Δ Δ

LFSA Data Collection Events

720 sec Data OFF 720 sec Data OFF 720 sec
Solar Array Performance (0,1Hz)
730 sec Data OFF 720 sec Data OFF 730 sec
Panel Temperatures (0.1 Hz)

8.0 REQUIRED MANPOWER

One civil servant (approx. 0.1 MY) would be required to evaluate telemetry data from the LFSA after launch.

9.0 REQUIRED FACILITIES

GSFC has the equipment to do electrical measurements on the LFSA (Large-Area Pulsed Solar Simulator or LAPSS).

10.0 SIGNATURES

IPDT Provider
Project Scientist
Project Manager
GSFC Program Manager
NMP Program Manager